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U.S. ENERGY FLOW - 1984

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ABSTRACT

The 1984 energy flow diagram for the U.S.A. has been constructed using Department of Energy data. It is a convenient graphical device to show supply and demand as well as the size of end-use sectors. A 4% increase in overall energy consumption represented a reversal in a downward trend started in 1979. All indicators pointed to more healthy industrial and farm economies in 1984 than in the previous two years, which accounted for some part of the increase in energy use. While domestic crude oil production remained stable, oil imports rose eight percent also reversing a long-standing trend. Seventy two million barrels of oil primarily from Mexico and the United Kingdom were added to the Strategic Petroleum Reserve bringing the total oil stored at year end to 451 million barrels. At the same time 49 million barrels of oil were produced from the government-owned Naval Petroleum Reserve #1 (Elk Hills, CA).

Energy use in all end-use sectors grew in 1984 which is in keeping with increases in use of all types of fossil fuels as well as electricity. Increase in electrical power demand continued to exceed forecasts, and during 1984 contracts for imports to the northeast U.S. were negotiated with Canada. Nuclear power contributed 15 percent of total power generated in the U.S. At year end there were 86 licensed reactors and 44 in either start-up or construction stages. Six were canceled or abandoned during construction during the year.

INTRODUCTION

United States Energy Flow Charts tracing primary resource supply and end-use have been prepared by members of the Energy and Resource Planning Group at the Lawrence Livermore National Laboratory since 1972.[1,2] They are convenient graphical devices to show relative size of energy sources and end-uses since all fuels are compared on a common Btu basis. The amount of detail on a flow chart can vary substantially, and there is some point where complexity begins to interfere with the main objectives of the presentation. The charts shown here have been drawn so as to remain clear and be consistent with assumptions and style used previously.

ENERGY FLOW CHARTS

Figures 1 and 2 are energy flow charts for calendar years 1984 and 1983[3], respectively. Conventions and conversion factors used in construction of the charts are given in the Appendix. For comparison with earlier years, consumption of energy resources is given in Table 1. These data represent substantial revisions by DOE (see Monthly Energy Review, March 1983, p. 36).

COMPARISON WITH 1983 AND EARLIER YEARS

1984 saw the reversal of long term declines in U.S. energy use. Not only did overall energy consumption increase but oil and gas use increased for the first year after steady declines since 1978-1979. Contributing to the overall increase in energy use was substantial increase in coal production. The largest share of the increase was related to fuel switching by the nation's

U.S. ENERGY FLOW - 1984
(NET PRIMARY RESOURCE CONSUMPTION 73 QUADS)

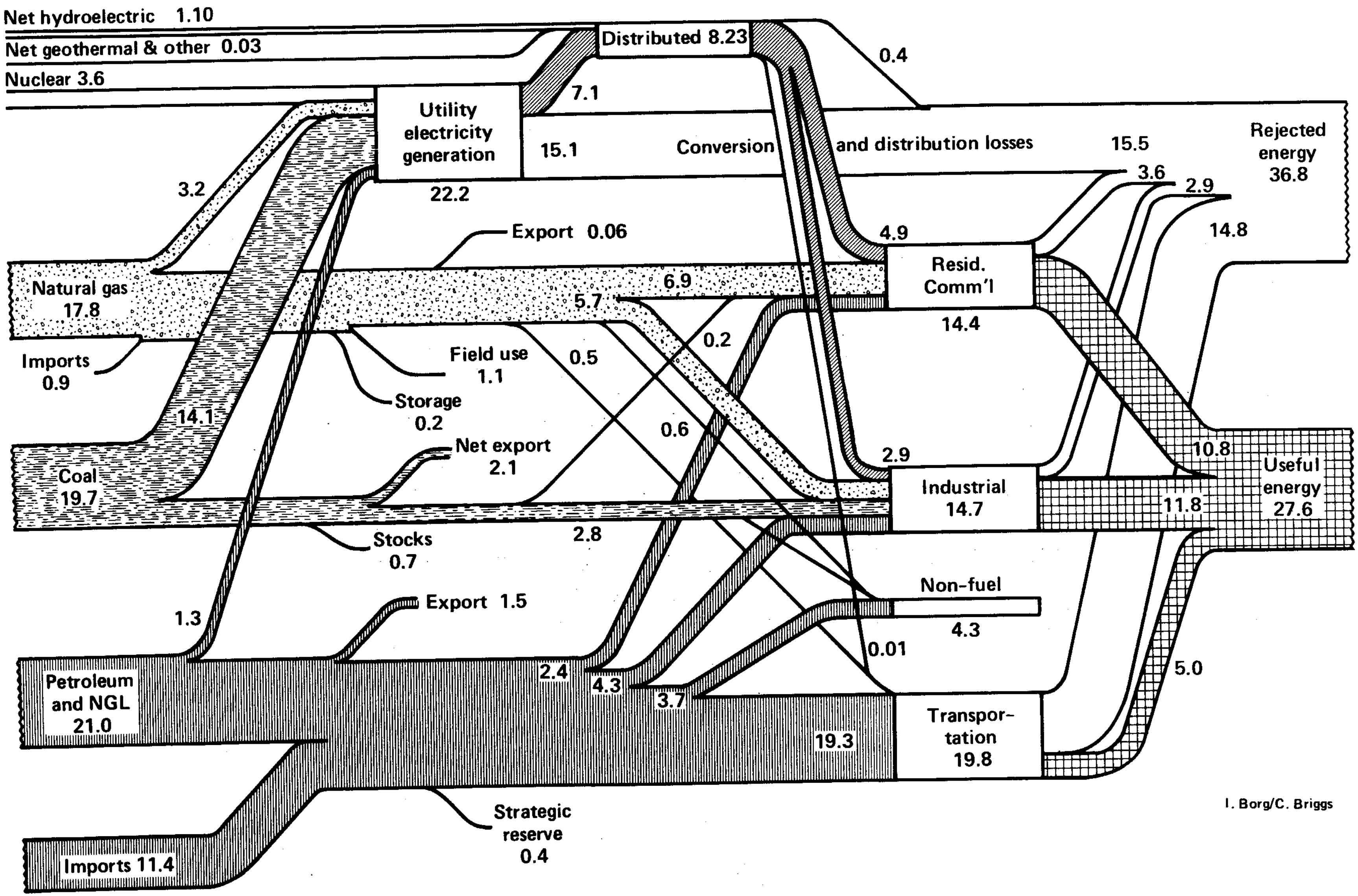


Figure 1

U.S. ENERGY FLOW — 1983
NET PRIMARY RESOURCE CONSUMPTION
70 QUADS

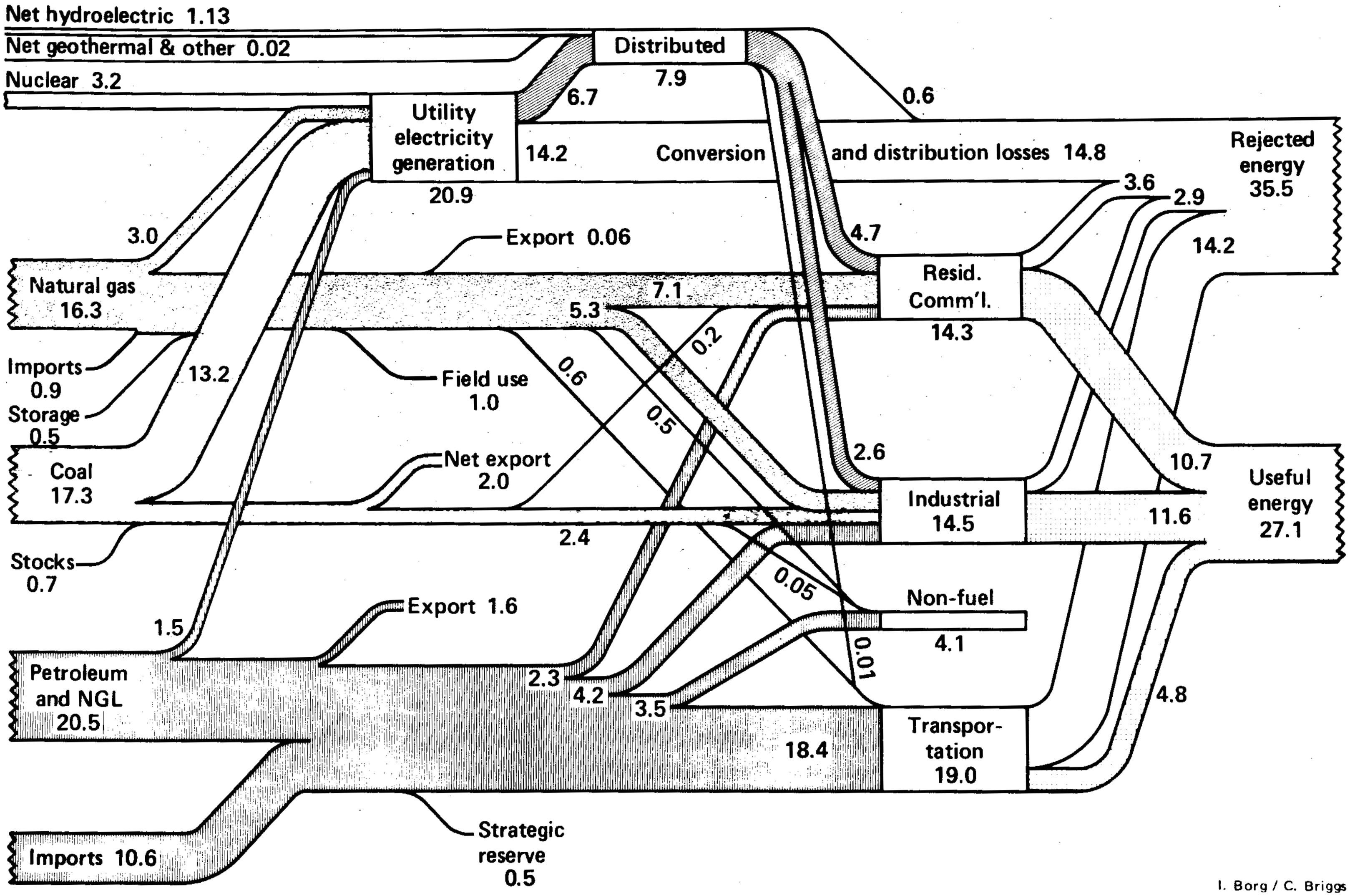


Figure 2

TABLE 1. COMPARISON OF ANNUAL ENERGY USE IN U. S.[4]

	Quads						
	1978	1979	1980	1981	1982	1983	1984
Natural gas	19.49	20.08	19.91	19.70	18.26	16.34	17.75
Imports	0.97	1.25	0.99	0.90	0.93	0.94	0.86
Crude oil and NGL							
Domestic crude & NGL	20.68	20.39	20.50	20.45	20.50	20.53	20.96
Foreign imports (incl products & SPR)	17.70	17.90	14.63	12.69	10.82	10.56	11.39
Exports	0.77	1.00	1.15	1.26	1.73	1.56	1.53
SPR storage reserve*	0.34	0.14	0.10	0.71	0.37	0.49	0.42
Net use (minus exports and SPR)	37.27	37.15	33.89	31.17	29.22	29.04	30.40
Coal (incl. exports)	14.86	17.48	18.54	18.33	18.60	17.29	19.70
Electricity							
Hydroelectric (utility) (net only)	0.96	0.95	0.94	0.89	1.06	1.13	1.10
Geothermal & other (net only)	0.01	0.02	0.02	0.02	0.02	0.02	0.03
Nuclear	3.02	2.78	2.74	3.01	3.12	3.22	3.55
Gas	3.30	3.61	3.81	3.76	3.34	3.01	3.21
Coal	10.24	11.26	12.12	12.58	12.58	13.23	14.09
Oil	3.99	3.28	2.63	2.20	1.57	1.54	1.29
Total fuel	21.52	21.90	22.26	22.46	21.69	22.15	23.27
Total transmitted energy	7.53	7.67	7.80	7.83	7.65	7.88	8.23
Residential and Commercial	16.03	15.71	15.09	14.55	14.64	14.29	14.48
Industrial	24.45	25.53	23.79	22.50	19.98	19.55	20.02+
Transportation	20.57	20.44	19.67	19.47	19.04	18.97	19.81
Total consumption** (DOE/EIA)	78	79	76	74	71	70	73

* Strategic petroleum reserve storage began in October, 1977.

+ Includes field use

** Note that this total is not the sum of entries above.

electrical utilities that has been on-going since the mid-seventies. Nonetheless increased industrial use of coal was also recorded. Increase in natural gas use occurred in the industrial end-use sector while residential, commercial and electrical utility use was stable.

Modest increase in oil consumption related to transportation demand, which increased for the first year since 1978. The increase was registered by both highway vehicles as well as by the air industry (Table 2). Motor gasoline sales rose while average miles traveled per gallon of fuel consumed continued to increase. The average is now almost 17 miles per gallon (m.p.g) for U.S. passenger cars. Since new cars represent only 10 percent of the auto inventory, mandated mileage improvements under The Energy Policy and Conservation Act of 1975 make small annual improvements in the overall fleet mileage. In 1974 new autos averaged 14.2 m.p.g., and the standard for 1985 is 27.5 m.p.g.

The nation's Strategic Petroleum Reserve continued to be filled and at the end of 1984 contained 451 million barrels (Table 3), 72 million barrels of which was added in 1984. Sixty percent of the oil was purchased from Mexico and the United Kingdom in almost equal amounts. At the same time the government produced 49 million barrels of oil from the government-owned Naval Petroleum Reserve #1 (Elk Hills, CA) which grossed $1.4 billion in FY 84. Elk Hills is the second largest producing oil field in the United States. Since it was reopened following the 1973 embargo, it has produced 439 million barrels. Thus Elk Hills production has nearly matched purchases for the Strategic Petroleum Reserve. During the early years of SPR filling, production at Elk Hills provided a measure of security against unexpected oil interruptions; however justification for continued production is not as clear.

TABLE 2. PETROLEUM PRODUCTS.*

	10^3 Barrels/Day (Average)								
	1976	1977	1978	1979	1980	1981	1982	1983	1984
Motor gasoline	6978	7177	7412	7034	6579	6588	6539	6622	6698
Jet fuel	987	1039	1057	1076	1069	1011	1010	1050	1170
Distillate fuel oil	3133	3352	3432	3311	2866	2829	2671	2690	2848
Residual fuel oil	2801	3071	3023	2826	2508	2088	1716	1421	1365

*Refined petroleum product supplied: sum of production, imports, net withdrawals from primary stocks minus exports.

Source: Monthly Energy Review, DOE/EIA-0035 (84/12); 1984 Annual Energy Review, DOE/EIA-0384 (84) April 1985.

TABLE 3. COMPARISON OF FILLING OF STRATEGIC PETROLEUM RESERVE AND PRODUCTION AT NAVAL PETROLEUM RESERVE #1 (ELK HILLS, CA)

Year	SPR Fill Million Barrels per year	NPR #1 ELK HILLS Production Million barrels per year	Estimated Remaining Reserves Millions of barrels at year-end
1974		0.84	
1975		0.77	
1976		11.7	996
1977	7	40.0	956
1978	60	45.2	911
1979	24	55.0	856
1980	17	58.9	930
1981	122	63.2	911
1982	64	59.8	851
1983	85	55.5	796
1984	72	49.4	746
Total	451	439 (1976-1984)	

Source: MER February 1985, p. 41; Annual Reports of the California Oil and Gas Supervisor, 1975 through 1983.

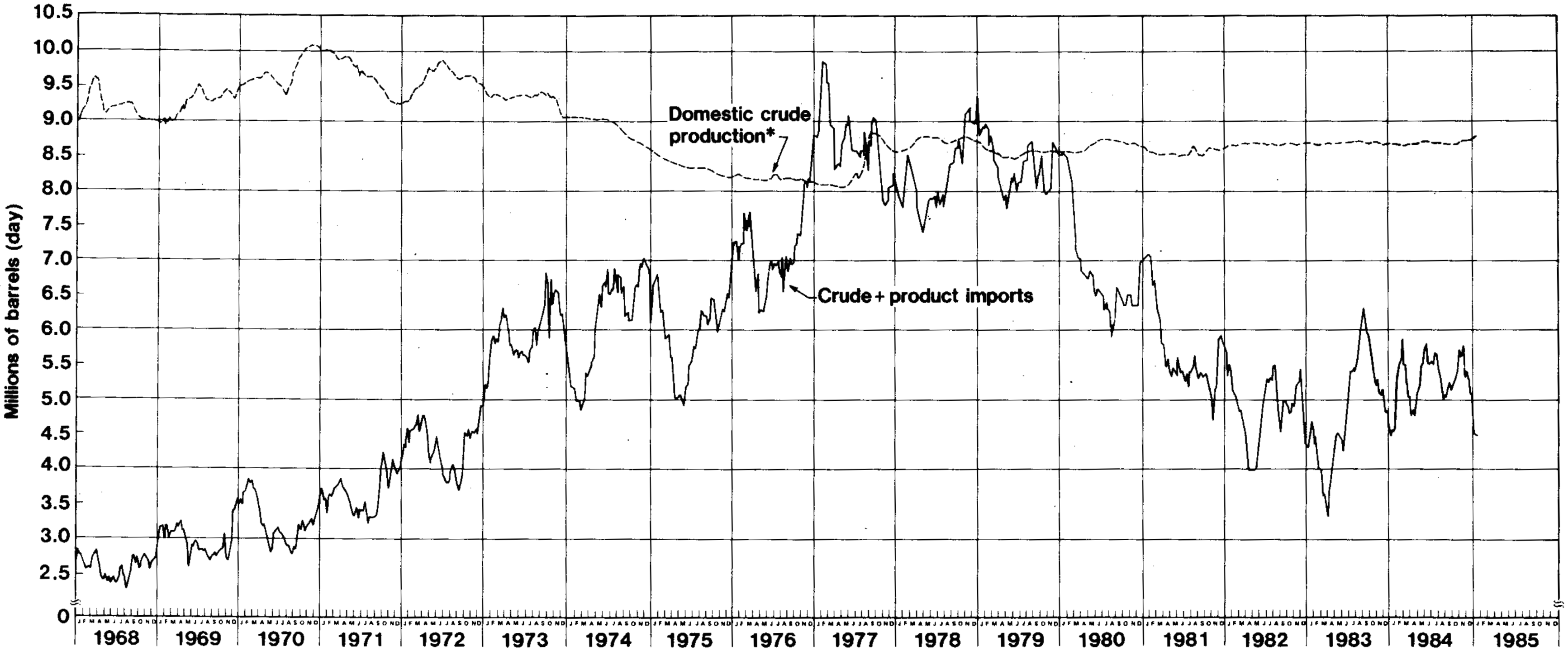
There are three other Naval Petroleum Reserves. Two are depleted, and the third on the North Slope of Alaska does not appear to contain significant quantities of oil despite extensive exploration.

Oil imports (crude plus products) increased almost 8% in 1984 (Figure 3). Falling oil prices worldwide (Figure 4) together with a vigorous economy encouraged the change and turnabout of the trend toward lower consumption that started in 1978. The main suppliers were Mexico, Canada and Venezuela, a member of OPEC, in decreasing order. OPEC supplied 38% of total imports, in marked contrast to the records of 67-69% in the 1977-1979 period.

U. S. electrical power output reached an all-time high the week ending August 11, 1984, and the annual increase in net electrical generation was 4.6%.(5) This rate of growth is larger than anticipated by forecasters. Much of the growth in demand is in the industrial Midwest and the New England areas. Both California and New England anticipate shortages in 1985.(6) Transmission problems to California may limit use of surplus power from the Pacific Northwest. In New England lack of new electrical generating capacity has posed problems of meeting increased demand. As an alternative to building new power plants New England utilities have contracted to purchase power from the government-owned utility, Hydro-Quebec in Canada. Contracts signed mid-year will result in imports equating to 10 percent of the supply of the 84 member New England Power pool. The surplus Canadian power will come from the hydro-electic facilities on the La Grange River which flows into James Bay, south of Hudson Bay. Ultimately the hydro-electric complex will have 10.3 GW_e capacity. It plans to sell to the New York Power Authority as well as to the New England Power pool. The surplus power relates to overestimation of electrical growth in Quebec.

PETROLEUM IMPORTS AND DOMESTIC PRODUCTION

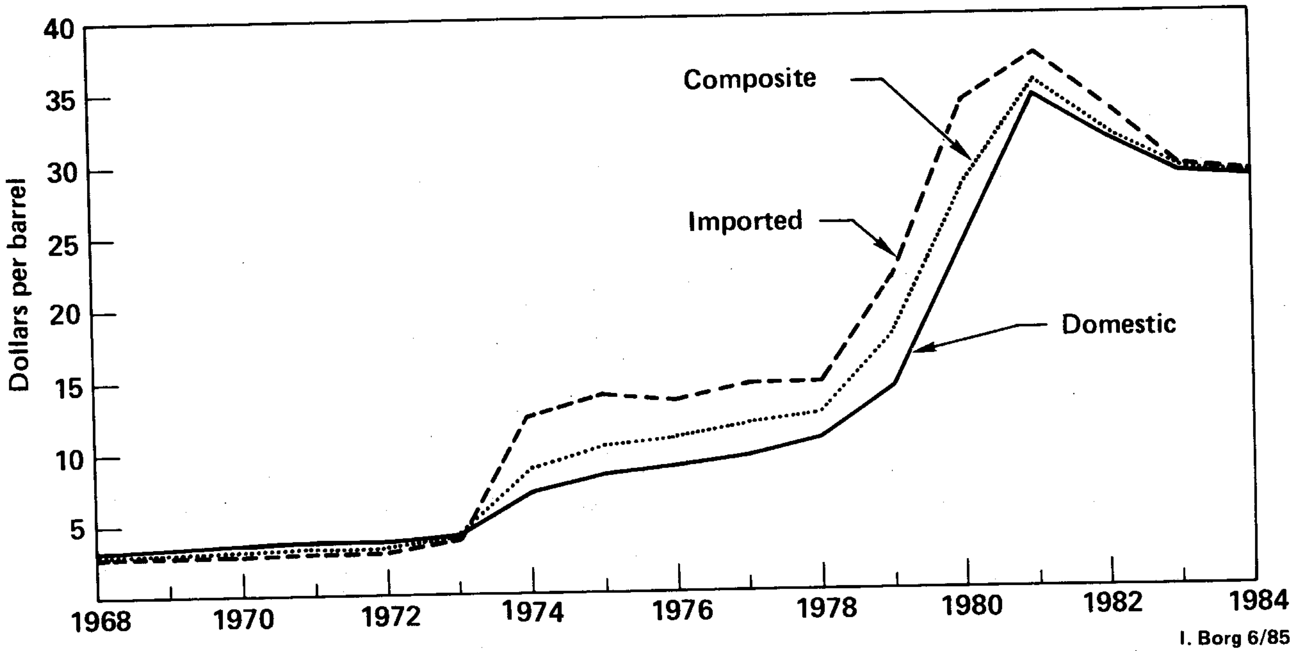
Moving four week average



*Note: NGL currently comprise an additional ~1.5 million barrels/day domestic oil production

Figure 3

REFINER ACQUISITION COST OF CRUDE OIL



Source: API Basic Petroleum Data Book, May 1985; Monthly Energy Review, Feb 1985.

Figure 4

In addition, power from New Brunswick province is imported to the northeastern states. One third of the output of the Point Lepreau 1 nuclear unit is exported to Maine and Massachusetts, and construction of a second unit dedicated to exports is under consideration. In both the New York and New England contracts with Hydro-Quebec, the price will float with the price of oil and coal and with the type of generation that is displaced by the imported hydro-electric power. Thus not all the cost advantages of hydro-electric power will be reaped by the northeastern utilities. Yet at 4 to 5 cents per kilowatt hour the utilities can easily justify the purchases since it is estimated that the two nuclear plants in the area nearing completion will produce power at somewhere between 12 and 20 cents per kilowatt-hour. An alternative to Canadian purchases is importing power from coal-fired plants in the Midwest. Arguments against this alternative are absence of power lines across New York and likelihood of problems associated with additional acid rain.(7)

Nuclear power's share of electrical generation was 15 percent in 1984, which is only slightly larger than its share in 1983. Six additional reactors became operable in 1984 bringing the total to 86. Six additional reactors are in a startup stage and 38 have construction permits. Two are on order, and the total is 132 in various stages of operation and completion. These 132 have a total design capacity of 123 GW_e. During 1984 six reactors were either canceled or abandoned. Four unfinished nuclear reactors were canceled by the Tennessee Valley Authority which indicated that any future power needs would be met by coal-burning plants. Consumers Power Co. in Michigan abandoned a nuclear plant that was 85 percent complete.(8) U. S. reactors operated an average 60 percent of the time in 1984, and Duke Power Co. in South Carolina achieved a 96.6 percent national record for its Oconee 2 reactor.(9)

1984 --- A strong economy

By all measures the U.S. experienced a good economic year. GNP (in 1972 dollars) rose 6.8 percent, net farm income in constant dollars increased almost 83 percent following the two farm recession years of 1982 and 1983. Unemployment fell to 1981 levels, and industrial production as measured by the Federal Reserve Board index rose 11 percent over 1983. Collectively this spelled increased energy demand in all end-use sectors. Nonetheless the increased demand (approx. 4.3%) was modest in the light of large increases in most economic indicators suggesting that conservation in all its forms continued to make inroads into energy usage.

Appendix

Data and Conventions Used in Construction of Energy Flow Charts

Data for the flow chart were provided by tables in the Department of Energy Monthly Energy Review, DOE/EIA-0035[4], the 1984 Annual Energy Review[10] and the Quarterly Coal Report, DOE/EIA-0121.[11]

The residential and commercial sector consists of housing units, non-manufacturing business establishments, health and education institutions, and government office buildings. The industrial sector is made up of construction, manufacturing, agriculture, and mining establishments. The transportation sector combines private and public passenger and freight transportation and government transportation including military operations.

Utility electricity generation includes power sold by both privately and publicly owned companies. The non-fuel category of end-use consists of fuels that are not burned to produce heat, e.g., asphalt, road oil, petrochemical feedstocks such as ethane, liquid petroleum gases, lubricants, petroleum coke, waxes, carbon black and crude tar. Coking coal traditionally is not included.

The division between "useful" and "rejected" energy is arbitrary and depends on assumed efficiencies of conversion processes. In the residential and commercial end-use sectors, a 75 percent efficiency was assumed which is a weighted average between space heating at approximately 60 percent and electrical lighting and other electrical uses at about 90 percent. Eighty percent efficiency was assumed in the industrial end-use sector and 25 percent in transportation. The latter percent corresponds to the approximate efficiency of the internal combustion engine.

There are some minor differences between total energy consumption shown here in the energy flow charts and the DOE/EIA totals given in Table 1. The differences relate to our conventions that exclude coal, natural gas and oil put into storage, e.g. crude oil dedicated to the Strategic Petroleum Reserve, from the totals. In addition, we use net hydroelectric power in flow charts rather than the gross amount, which is customarily included in DOE/EIA totals. Thus the sum of individual contributions to annual energy consumption shown in the energy flow charts will be smaller by several quads (10^{15} btu) than total published by DOE/EIA and given at the top of the chart and in Table 1.

Conversion Factors

The energy content of fuels varies. Some approximate, rounded conversion factors, useful for estimation, are given below.

Fuel	Energy Content (Btu)
Short ton of coal	22,400,000
Barrel (42 gallons) of crude oil	5,800,000
Cubic foot of natural gas	1,000
Kilowatt hour of electricity	3,400

More detailed conversion factors are given in the Department of Energy's *Monthly Energy Review*.

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